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Applying Web-Based Tools for Research, Engineering, and Operations

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Applying Web-Based Tools for Research, Engineering, and Operations

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Abstract

Personnel in the NASA Glenn Research Center Network and Architectures branch have performed a variety of research related to space-based sensor webs, network centric operations, security and delay tolerant networking (DTN). Quality documentation and communications, real-time monitoring and information dissemination are critical in order to perform quality research while maintaining low cost and utilizing multiple remote systems. This has been accomplished using a variety of Internet technologies often operating simultaneously. This paper describes important features of various technologies and provides a number of real-world examples of how combining Internet technologies can enable a virtual team to act efficiently as one unit to perform advanced research in operational systems. Finally, real and potential abuses of power and manipulation of information and information access is addressed.

Introduction

Much of the research performed by personnel in NASA Glenn Research Center's Network and Architectures branch is directed towards communication protocol development, network centric operations, and secure mobile networking. In order to address real-world operational deployment implications —particularly with regard to security—much of the research has been performed in operational systems owned and operated by various entities and connected via the Internet. Almost all efforts are via remote operations with multiple parties located throughout the world. Timely communication and common situational awareness are critical for mission success. This has been accomplished using a variety of Internet technologies.

This paper describes many of the Web-based tools available that provide efficient communication, collaboration, and information sharing and dissemination. A number of real-world examples are given showing how combining Internet technologies can enable a virtual team to act efficiently as one unit to perform advanced research in operational systems. Finally, real and potential abuses of power and manipulation of information and information access are addressed.

To date, we have not utilized social media networks such as blogging services, Facebook, MySpace or Twitter as other technologies appear to better serve a team environment and provide better security control. Some of the technologies that will be covered include: email and mail list servers, Web servers, Wikis, teleconferencing, audio streaming, instant messaging, Web-based meetings, version control systems, issue trackers and publish/subscribe Web telemetry servers.

Mobility: How People Work Today

Before we examine the various Web-based technologies and how they have been applied to improve our communications and work efficiencies, it is worth reviewing how people work today.

- People work globally.
- The world runs 24 hr a day.
- People work across time zones—often, global time zones.
- People are mobile (locally and globally).
- Wireless is the norm.
- Always on connectivity (at least if one does not intentionally disconnect) is the norm.
- It is not uncommon to be on a teleconference while sitting in an airport or taxi or car or train.
- People operate in a virtual environment and multitask.
- One does not have to be physically present to participate.
- Technology allows one to time-shift information.
- Machines do not care what time it is, people do.

This is Reality

The author resides in the Eastern United State time zone. He participated in an early morning teleconference with colleagues in Europe. The author was also required to participate in a late-day (Pacific Time Zone) teleconference In order to fulfill both obligations and maintain a reasonable family life, the second teleconference was handle from home (telecommuting). The wireless phone was muted. The laptop was on the kitchen table with the charts up. The grill was ready for cooking. The table was being set and food was being prepared. Multitasking!

The author received an email from a working group chairman asking to present at a meeting in Prague, Czech Republic. The author was in Cleveland, Ohio. The meeting was from 17:40 to 19:50 Prague time (11:40 a.m. in Cleveland). The email came the night before the meeting. The presentation was placed on a Web server. A colleague at the Prague meeting volunteered to give the presentation. The colleague presented while the author listened via a live MP3 audio feed accessed from his laptop, which was connected to the Internet via a broadband card. The author was at the auto repair center at this time. The questions were heard, and responded to via instant messaging (Jabber) in a chat room set up for this meeting. The chairman monitored the instant message chat room and relayed responses to the meeting attendees. It worked. Technologies utilized included email, file and Web servers, MP3 audio streaming, instant messaging (chat rooms) and broadband mobile internet access.

Web Applications and Technologies

Voice

When considering human interaction, there is no substitute for voice communication. It provides human contact that is essential to building trust. One can also hear emotions and voice inflections that provide additional information not conveyed in text. So what makes the Internet so special with regards to voice? The answer is Voice over Internet Protocol (VoIP). VoIP has dropped the price of international voice communications to a few cents per minute or less. In addition, teleconferencing is available to all. Finally, most, if not all landline telephone communication is converted to Digital and VoIP, so even land line costs have dropped dramatically making it easier to communicate internationally—from home. Being able to phone from home is important because that extends the contact time for international communication—8:00 a.m. in Tokyo, it is 7:00 p.m. on the east coast of the United States.

Teleconferencing

Teleconferencing is a mature technology. It is simple and works well. With today's VoIP technologies, someone from half way around the Globe can participate for a few cents per minute. If information is distributed early or placed on a file server, teleconferencing can be as effective or perhaps more effective than Web-based meetings. If documents are distributed early, participants can prepare and can participate while on a low bandwidth mobile phone sitting in a taxi or book store or coffee shop—although the latter two may have Web access and low bandwidth phones are becoming dinosaurs.

Mobile Phones

Mobile phones are not just phones anymore. Mobile phones are now network appliances with multitasking capabilities. Bandwidths for 4G are in the Mbps range. With such bandwidth, one can talk while sending video, downloading files, reading email, and browsing the Web. Some phone can even act as Wi-Fi hotspots.

Email and Mail List Servers

For all practical purposes, everyone has email. Many have multiple accounts. In addition, one can send large files to large groups via email (not that this is the best way to distribute such information).

Many people also subscribe to mail lists. Many companies and government agencies run mail list servers and new mail lists can be setup by their employees. There are also free mail list servers available. Some of the advantages of mail list servers include the ability to archive and review archives of discussions, control of the group, an ability to see who is included in the group, and bulk delivery. Do not underestimate the usefulness of archiving discussions. Generally, these archives can be searched and sorted by date, topic, thread, or author.

Web Servers

Web servers are simple and quick to set up and use. Most people with high-speed Internet access probably are provided with some space to create a personal limited capacity Web site. All major companies have internal and external Web servers. There are also numerous software packages available to create sophisticated Web sites or very simple Web sites without having to learn the hypertext language.

Web servers provide a publish/subscribe environment. The main issue is access. Who is permitted to publish and who is permitted to subscribe. Information, documents, papers, presentations, video and just about anything one can think of can be made available on a Web page. All a subscriber needs to do to obtain that information is point to the site with a browser and click. Social media sites such as Facebook, Twitter, Flicker, and YouTube are just specialized applications running on Web servers and certainly could be considered personal Web sites.

Wikis are Web servers that provide a simple way to edit Web pages without having to be an expert. Wikis are an excellent way to distribute information quickly. They are a publish and subscribe architecture. Wikis are often set up to allow multiple editors or even full pubic editing. Access can be limited in a number of ways included access lists or physical access. In addition, publication privileges are readily controlled.

Audiocasting and Podcasting

Audiocast is digital audio content generally available on the Internet. Audiocast can be in the form of real-time streaming or via archived files. These archived files are available via the Web and often termed podcast although podcast could include video as well.

The Internet Engineering Task Force (IETF) is a large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. It is open to any interested individual. For many years, the IETF has audiocast their meetings over the Internet enabling anyone to remotely participate in the meetings. This helps with travel issues (i.e., money, time, foreign entry) as the IETF meets three times a year and moves those meetings around the globe. Everybody at the meetings must use the microphone so that remote listeners can hear as the audio is picked up from the microphones. A byproduct of the audiocast is that these audio streams are archived. Thus, anyone can listen to an archived meeting at any time. Since the presentations are also archived, one can view the charts and listen to the stored audio presentation at a convenient time.

Video

With today's technology, it is very easy for individuals to make videos. One can even capture the information as it occurs on a computer screen and turn that into a video. These videos can then be place on Web servers. Videos are created for entertainment, advertising, promotion, publication, tutorials, or documentation. YouTube is one of the better-known Web sites for an individual to upload videos for mass distribution. One can also upload video to social media sites such as Facebook thereby limiting distribution to only those you have allowed access.

Instant Messaging

Originally, instant messaging was strictly text based. Today, instant messaging can include audio chat and video conferencing as well as file sharing, and archiving services. Most instant messaging now has some form of security features.

Instant messaging can be between two users, but is also very useful as a real-time group discussion tool. This is accomplished using chat rooms. As with email list servers, the archiving services provided by some instant messaging tools can be quite valuable.

Virtual Network Computing

Virtual Network Computing (VNC) is a graphical desktop sharing system to remotely control another computer over a network connection. VNC was originally developed at the Olivetti Research Laboratory in Cambridge, United Kingdom and was available as open source. Numerous remote monitoring and control software packages are now available. Some are free and others are for purchase. Such software enables one to see the desktop of a remote machine and control it with your local mouse and keyboard, just like you would do it sitting in the front of that computer. This generally requires reasonable bandwidth and can be rather slow over low bandwidth or long delay links.

VNC software is invaluable for remote access to control systems as well as for training. Using VNC technology, an expert no longer is required to be co-located with the control system. Furthermore, untrained users can learn from a remote expert by "virtually" looking over the expert's shoulder during live operations without being co-located with that expert.

Web-Based Meeting Services

Web-based meetings are a technology that often combines application and/or desktop sharing VNC with tele-conferencing and instant messaging. Some software tools allow users to only share display of desktops while others allow remote users to take over control of the remote system. Some Web-based meeting tools also include voice and video as well as desktop sharing. The ability to remotely view and control a machine implies that Web-based meeting services can be used for other than just meetings. It is important to note that Web-based meeting services require a reasonable amount of bandwidth. Therefore, it is often more effective to simply distribute meeting materials prior to the meeting and hold a teleconference.

Version Control Servers

Version control software is readily available including commercial packages as well as many free open source packages. Version control software is most often used by computer programmers to collaborate, maintain and document software changes. However, such version control servers can be readily adapted to non-software documentation. With version control, one can quickly revert back to older versions of documents. Generally when a revised document is uploaded to the version control server, some text or notation is added to the metadata indicating what changes were made thereby enabling remotely diverse collaborators to understand what revisions and updates were made to the documents. This is particularly true for software as one can display the differences between two files, or each corresponding file in two different directories.

Web Collaboration Software and Servers

Web collaboration software provides a uniform integrated portal that combines many of the tools previously discussed including video or voice conferencing, email and instant messaging and white boarding. These Web-based collaboration software tools enable the sharing of information by providing an intranet-based environment for virtual teamwork (Ref. 1). They also provide a fairly high degree of security management. Few Web collaboration software packages are free and many tend to combine a particular company's products whereas all of the previous tools discussed can be obtained free of charge and many are open source software.

Case Studies

Internet Protocols in Space: Testing and Troubleshooting

During the spring of 2004, a demonstration of the Office of Secretary of Defense (OSD) space-based network centric operations concepts and major elements of the National Reconnaissance Office (NRO) Transformal Communication Architecture (TCA) was successful completed using technology based around the Internet Protocols (Ref. 2). A key element of this demonstration was the ability to securely use networks and infrastructure owned and/or controlled by various parties. The demonstration involved the United States Army, Air Force and

NASA as well as US and foreign commercial companies. Two transmit and receive and one receive-only ground stations located in Guldford, England, North Pole Alaska and Colorado Spring Colorado, respectively were used.

The remote user (warfighter) operations were conducted out of Vanderberg Air Force Base, California. In order to coordinate during troubleshooting and testing we utilized a number of Internet communication technologies as well as teleconferencing.

Instant messaging was extremely useful as it provided an out-of-band communication channel during teleconferences and live testing. This reduced chatter on the teleconference as well as in the control rooms where much information is being communicated over intercom systems. The first information that was conveyed was that someone had logged into the system and therefore was there and working. The other information conveyed was more in the line of today's text messaging. (e.g., "Receiving RF", "Modem Locked," "Receiving Telemetry").

Email list servers were established for various groups to broadcast status and critical information to the appropriate teams.

General Dynamics, as part of their work with Army Space and Missile Defense Command Battle Lab, developed a Virtual Mission Operations Center (VMOC). One of the features of this secure portal was the ability to receive satellite telemetry from three participating ground stations. In this demonstration the SSTL United Kingdom Disaster Monitoring Satellite (UK-DMC) was used. The UK-DMC had a Cisco Router onboard. The telemetry from this satellite could be displayed in real-time by anyone with access privileges to the VMOC. Since this was a Web-based service with portions constructed in a publish/subscribe architecture, all participants could have access to the telemetry. Universal Space Network (USN) and Integrated Applications Incorporated used the real-time telemetry to debug their ground stations. For example: USN was able to validate, in real-time, that they were tracking the satellite and transmitting at proper frequency and power levels by monitoring the receiver power. In this instance, receiver power at the satellite was to be between approximately –100 to –90 dBm. There are two receivers corresponding to two frequencies as illustrated in Figure 1. USN was transmitting on a frequency that is received by the top entry.

Occasionally, a user did not have access to the VMOC as there was either a one-time need or it was impossible to instantaneously provide access privileges. In those cases, an impromptu WebEx meeting was setup and the desktop display of a machine that did have access to the VMOC was pushed out to those individuals or groups that subscribed to the WebEx meeting. In such instances, the telemetry screen in Figure 1 was projected out via WebEx from a user that had access to the VMOC.

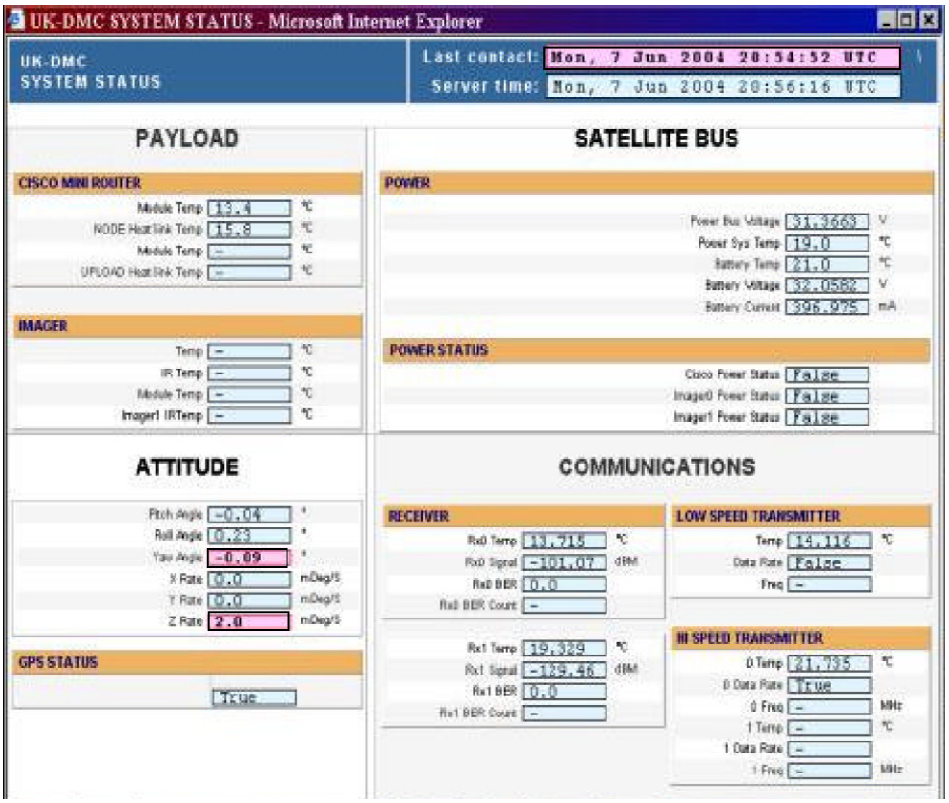

Figure 1.—Real-time telemetry.

Delay Tolerant Networking (DTN) Disconnectathon

On July 29 and 30 of 2009, the Internet Research Task Force (IRTF) Delay Tolerant Networking Research Group (DTNRG) held a DTN interoperability event at the Internet Engineering Task Force (IETF) meetings in Stockholm, Sweden. The event was named Disconnectathon. Participating sites (DTN network nodes) were spread throughout the United States and Europe with nodes at Ohio University in Athens, Ohio, a node in Cleveland, Ohio, nodes at Trinity College in Dublin, Ireland, and a variety of nodes at the IETF meeting. Figure 2 shows a hand draw diagram of some portions of the interoperability network that were constructed on site. This diagram was uploaded to a Web server and a hyperlink place on the DTNRG wiki to provide all participants with real-time situational awareness.

In the past, to perform interoperability tests, a large switch or hub was setup in a room and people connected their machines to that hub. Everything and everyone had to be co-located. For this interoperability experiment, machines could come and go from the network as disconnection is assumed a normal operating mode for DTNs. The IETF meeting wireless network infrastructure provided connectivity for the local machines. One did not have to be in any specific room or tied to a wired system. Experiments were run while researchers were participating in meetings in various rooms throughout the conference center. There was no need for everybody to be co-located. This was accomplished by having Ohio University setup a dynamic domain name server (DNS) and everybody registered their addresses with that DNS. Ohio University then periodically updated and published the DNS entries on a Web server to aid in configuration of static routes—as static routing was all that was used during these interoperability experiments (Table 1). Finally, any useful information to aid in the interoperability tests was published on the DTNRG wiki at the Disconnectathon site including all configurations and contact information (Ref. 3).

In order to communicate over time zones, in various remote locations and various rooms a teleconference number and a special email list server and collaboration site were established. Since DTNRG already had an instant messaging broadcast textual communications to the participants. It turned out that the chat room was the most useful way to communicate. Everyone in the chat room had the same situational awareness. Furthermore, the jabber chat room provided an archiving feature and allowed users to review older conversations that they may not have seen while finally, participants often were in locations where voice communications would have disturbed others.

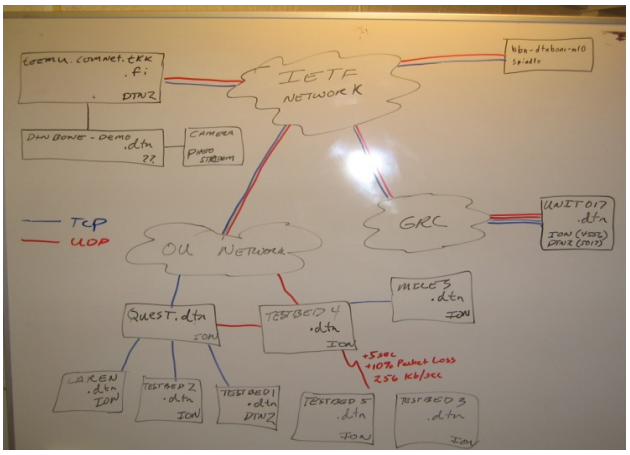

Figure 2.—Disconnectathon network diagram.

TABLE 1.—REDUCED SET OF ENTRIES FROM DISCONNECTATHON DYNAMIC DNS

dtnbone.ocp.ohiou.edu name server lin5.its.ohiou.edu. < ---server URL
bbn-dtnbone-m04.dtnbone.ocp.ohiou.edu has address 130.129.20.132
daedalus.dtnbone.ocp.ohiou.edu has address 75.180.14.85
dax.dtnbone.ocp.ohiou.edu has address 132.235.232.105
dtngateway-2-200.dtnbone.ocp.ohiou.edu has address 130.129.51.245
dtnmule-2-10.dtnbone.ocp.ohiou.edu has address 130.129.52.243
dtnmule-2-31.dtnbone.ocp.ohiou.edu has address 130.129.53.239
haruman.dtnbone.ocp.ohiou.edu has address 132.235.3.41
jishac-laptop.dtnbone.ocp.ohiou.edu has address 130.129.37.254
laren.dtnbone.ocp.ohiou.edu has address 132.235.67.81
miles.dtnbone.ocp.ohiou.edu has address 132.235.67.20
sphere.dtnbone.ocp.ohiou.edu has address 130.129.23.175
teemu.dtnbone.ocp.ohiou.edu has address 130.129.21.129
dtnbone.commet.tkk.fi (Camera Application) <---- Reg in other DNS

Use of Wikis and Web servers proved useful—particularly to monitor remote operations for trouble shooting purposes. One could not assume a human was available to help due to the discrepancy in time zones and continuous interoperability testing. One example of use of Web servers is shown in Table 2. Ohio University periodically published the DTN log files from its various DTN nodes. The particular snapshot of the log file shown in Table 2 is of the Ohio University DTN gateway machine, QUEST (Fig. 2). One could remotely view these log files and determine if DTN bundles were being received properly and, if they died at the Ohio University site. Many of the techniques used during this Disconnectathon have been incorporated into remote monitoring of nodes on the DTNbone (Refs. 4 to 6).

TABLE 2.—SNAPSHOT OF DTN LOG FILE FOR OHIO UNIVERSITY "QUEST" DTN NODE

/07/30 05:50:42] at line 322 of ./bp/tcp/tcpcli.c, tcpcli couldn't receive contact header: Connection reset by peer
/07/30 05:50:42] at line 1045 of ./bp/tcp/libtcpcla.c, Could not receive contact header magic.
/07/30 05:45:36] at line 322 of ./bp/tcp/tcpcli.c, tcpcli couldn't receive contact header: Connection reset by peer
/07/30 05:45:36] at line 1045 of ./bp/tcp/libtcpcla.c, Could not receive contact header magic.
/07/30 05:42:00] at line 111 of ./bp/dtn2/dtn2fw.c, Can't find forwarding directive for EID. (dtn://basil.dsg.cs.tcd.ie.dtn/tracer
/07/30 05:40:35] at line 322 of ./bp/tcp/tcpcli.c, tcpcli couldn't receive contact header: Connection reset by peer
/07/30 05:40:35] at line 1045 of ./bp/tcp/libtcpcla.c, Could not receive contact header magic.
/07/30 05:38:41] at line 111 of ./bp/dtn2/dtn2fw.c, Can't find forwarding directive for EID. (dtn://basil.dsg.cs.tcd.ie.dtn/tracer
/07/30 05:38:34] at line 111 of ./bp/dtn2/dtn2fw.c, Can't find forwarding directive for EID. (dtn://basil.dsg.cs.tcd.ie.dtn/tracer
/07/30 05:35:35] at line 322 of ./bp/tcp/tcpcli.c, tcpcli couldn't receive contact header: Connection reset by peer
/07/30 05:35:35] at line 1045 of ./bp/tcp/libtcpcla.c, Could not receive contact header magic.

Multiterminal Delay Tolerant Networking Experiments

The NASA Glenn Research Center (GRC) has performed a number of DTN multiterminal experiments using SSTL and USN infrastructure (Ref. 7). Personnel from Japan's National Institute of Information and Communication (NICT) and the Japan Manned Space Systems Corporation *(*JAMSS) expressed interest in performing joint DTN experiments using NICT's ground station in Koganei, Japan. Funding was available for only two satellite pass attempts. There was little margin for error or time or resources for training. Therefore, NICT and JAMSS agreed to allow NASA GRC personnel to have remote access to their systems to run the commands. In order to allow NICT and JAMSS personnel to view the commands being entered during satellite passes, Virtual Network Computing (VNC) software was installed on the local controller machine at the Koganei site and on a remote access machine at GRC. This enabled GRC personnel to remotely control the experiment while NICT and JAMSS personnel viewed locally. GRC personnel could have used remote access via secure shell[1] and X-windows[2] to run the tests, but local personal in Japan would not have been able to view operations. VNC allowed for full transparency as personnel in Japan could view in real-time the commands being issued by GRC personnel.

[1]Secure Shell (SSH) is a network protocol that allows data to be exchanged using a secure channel between two networked devices.
[2]X Window System is a computer software system and network protocol that provides a graphical user interface for networked computers.

NASA Real Time Mission Monitor (RTMM)

The NASA Real Time Mission Monitor (RTMM) is a Web-based situational awareness tool. It uses a service-oriented architecture based on community standards and protocols. Utilizing RTMM, multiple users remotely located are able to obtain the same situational awareness. In addition, each user can customize the information presented. The RTMM continues to evolve and currently integrates satellite, airborne and surface data sets; weather information; model and forecast outputs; and vehicle state data for field experiment management (Ref. 8).

One recent program that has utilized the RTMM was the Genesis and Rapid Intensification Processes (GRIP) experiment. The goal of GRIP was to better understand how tropical storms form and develop into major hurricanes. One of the experiments took place on September 16 and 17, 2010 when three NASA aircraft jointly collected data on what became hurricane Karl.

Figure 3 shows aircraft flight tracks for the DC-8 and WB57. Other information that is available from the RTMM includes, but is not limited to: aircraft waypoints, lightening strikes, and near-real-time research data output.

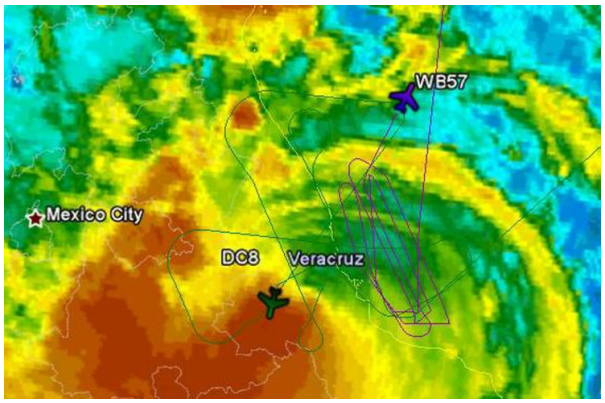

Figure 3.—RTMM aircraft tracks display.

Issues

Information Control

Once information is on the open Internet, there is very little one can do to remove that information.

Web collaboration software written for business enterprises provides security features that help control information flow (i.e., information access control, publishing control, etc...). These restricted social media tools generally reside behind the corporate firewalls and usually limit access to only employees physically inside the network or with restricted remote access privileges.

Web 2.0 technologies are commonly associated with Web applications that facilitate interactive information sharing, and user-centered design. Web 2.0 sites provide users the free choice to rapidly interact or collaborate with each other.

What is corporate policy when considering use of Web 2.0 technologies for business applications? Is use of Web 2.0 technology on the open Internet allowed? What happens if one wishes to utilize Web 2.0 technology for international collaboration or collaborations across organization? Note, individuals do not always follow policy and may take whatever steps are necessary to get the job done.

Social Media sites outside the corporate firewall are accessible via the Web using standard Web browsers. Most corporations' firewalls are inbound centric. Firewalls block inbound traffic originating from outside sources. Very few corporate networks restrict outbound access to the Web—although they may restrict access to particular sites. Therefore, the ability to control information is quite problematic and getting more difficult every day. Employee training is vital to ensuring sensitive information does not reach unintended audiences.

Abuses

Just as one can abuse Web 2.0 by distributing information that should be restricted, one can also use tools that restrict access to inhibit communication and collaboration for an individual's or entity's own purposes. For example, one may wish to give the impression of open discussion while actually controlling the information flow. One might control access to or quietly removed individuals from a mail list server if one determines that dissenting opinions are not in the best interest of the list or Wiki controller. To avoid such instances, some open organizations such as the Internet Engineering Task Force have very clear procedures for restricting access (Refs. 9 and 10). Other organizations do not and have such policies in place resulting in individual's implemented practices such as silently removing dissenting opinions.

Conclusions

Internet technologies help enable a free flow of information and collaboration. Much of this technology is free, openly available. Furthermore, it takes very little time to become a reasonably proficient user.

Open collaboration tools have been critical to enabling mission success as validated by the case studies presented. Such tools enable free flow of communication, real-time communication, improved situational awareness, and remote operations and testing. Indirect benefits include: reduced travel costs, information and communication archiving, and better utilization of remote experts for operations and training.

Enterprise level collaborative software enables corporations and institutions to place security and controls on the information within these systems. However, that does not ensure that individuals or groups will only collaborate within such closed systems.

Employee training is vital to ensuring sensitive information does not reach unintended audiences or leave the corporate network. Once it does, there is very little one can do to get it back.

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Biography

William Ivancic has over twenty-seven years of experience in network and system engineering for communication applications, communication networking research, state-of-the-art digital, analog and RF hardware design and testing. He currently is a senior research engineer at NASA's Glenn Research Center. Of particular interest is large scale, secure deployment of mobile networks including mobile-ip and mobile router technology. Mr. Ivancic is currently working on communication protocols and network designs to improve the data delivery for Unmanned Aeronautic Vehicles (UAVs).

Mr. Ivancic is also principle of Syzygy Engineering, a small consulting company specializing in communications systems and networking as well as advanced technology risk assessment. Mr. Ivancic is currently performing research and development on Identity-based security and key and policy management and distribution for tactical networks—particularly mobile networks.

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14. ABSTRACT
Personnel in the NASA Glenn Research Center Network and Architectures branch have performed a variety of research related to space-based sensor webs, network centric operations, security and delay tolerant networking (DTN). Quality documentation and communications, real-time monitoring and information dissemination are critical in order to perform quality research while maintaining low cost and utilizing multiple remote systems. This has been accomplished using a variety of Internet technologies often operating simultaneously. This paper describes important features of various technologies and provides a number of real-world examples of how combining Internet technologies can enable a virtual team to act efficiently as one unit to perform advanced research in operational systems. Finally, real and potential abuses of power and manipulation of information and information access is addressed.

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